Instruction book

Energy Recovery

For GA75-110VSD+ (2017)

Partnr. 9820 3002 14

Edition 00

Preface

This instruction is written to explain the main components and the functional working principle of the new generation of energy recovery units currently used as an option feature in the oil injected screw compressor ranges from GA75VSD+ up to 110VSD+[1].

For the sake of convenience, the terms “energy recovery” and “energy recovery unit” will sometimes be abbreviated as “ER” and “ER-unit”.

[1] This includes **GA75VSD+, GA90VSD+, GA110VSD+**

Contents

1 Energy recovery (ER)

1.1 Description

The energy required in any compression process is mainly transformed into heat. For the Atlas Copco GA oil-injected screw compressors, the major part of this compression heat is dissipated through the oil system. The Atlas Copco energy recovery system is designed to recover most of the above mentioned heat by transforming it into warm/hot water without any adverse influence on the compressor performance. The water can be used for diverse applications.

1.2 Components

The energy recovery system is completely integrated and mainly comprises:

- Complete **stainless steel** oil/water plate heat exchanger.
- Thermostatic bypass valve with on/off handle.
- Temperature sensors for water inlet en outlet control.
- The necessary bolts, pipes, hose assemblies, etc.
- The energy recovery system also includes thermostats for both the bypass valve of the energy recovery unit and the main bypass valve of the main coolers.
- Pressure relief valve with a set pressure of 10bar.

1.3 Energy recovery unit (ER-unit)

1.3.1 GA75VSD+, GA90VSD+, GA110VSD+

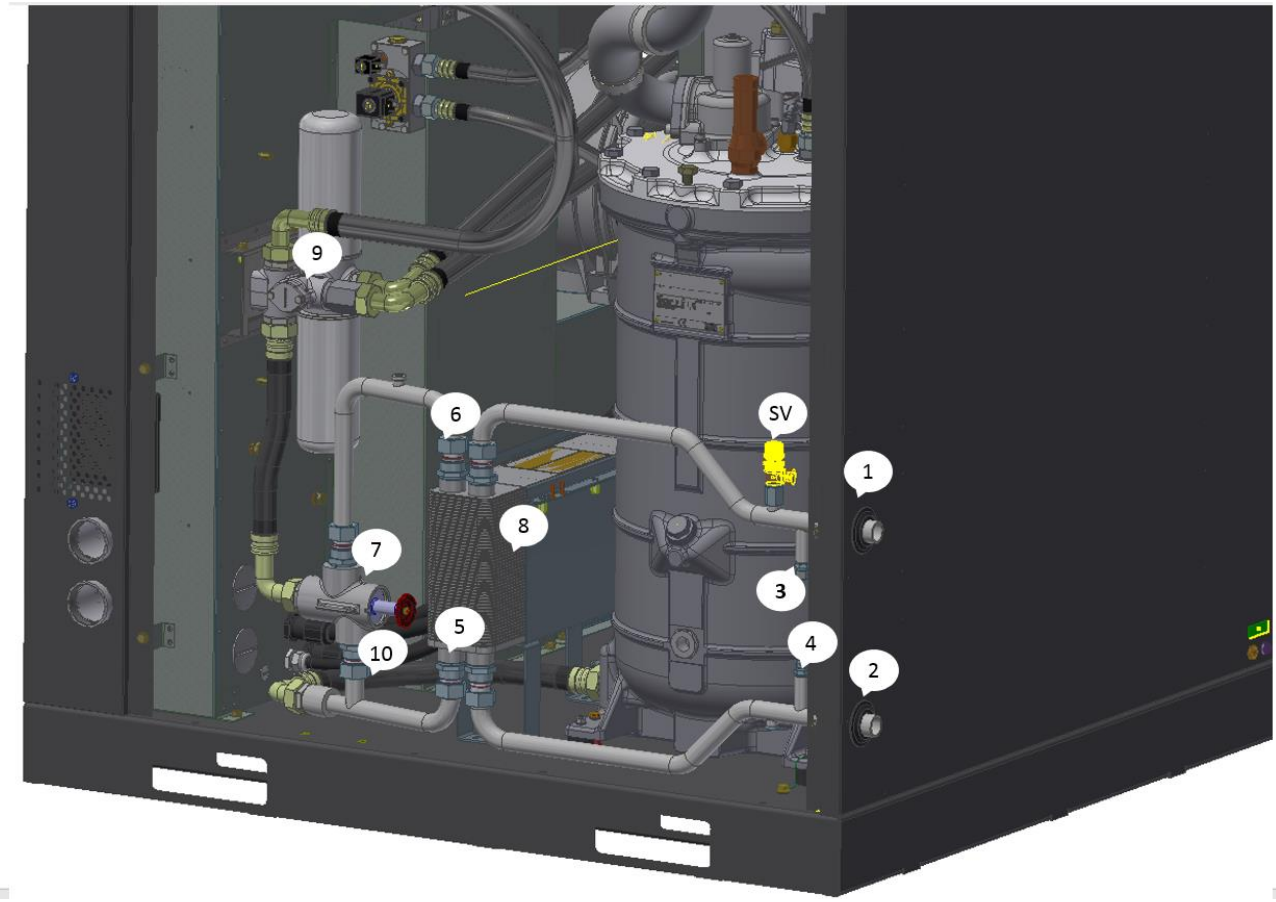

Figure 1: Energy recovery for GA75-110VSD+

Reference in Figure 1	Designation
1	Water inlet connection
2	Water outlet connection
3	Temperature sensor, water in
4	Temperature sensor, water out
5	Oil inlet connection
6	Oil outlet connection
7	Thermostatic valve ER-unit (1st Bypass valve)
8	Heat exchanger (of ER-unit)
9	Thermostatic valve oil coolers (2nd Bypass valve)
10	Energy recovery bypass connection
SV	Pressure relief valve

1.4 Mechanical adaptations & installation

When working on the unit take in account the safety precautions as described in the instruction book of the compressor.

1.4.1 GA75-110VSD+ range

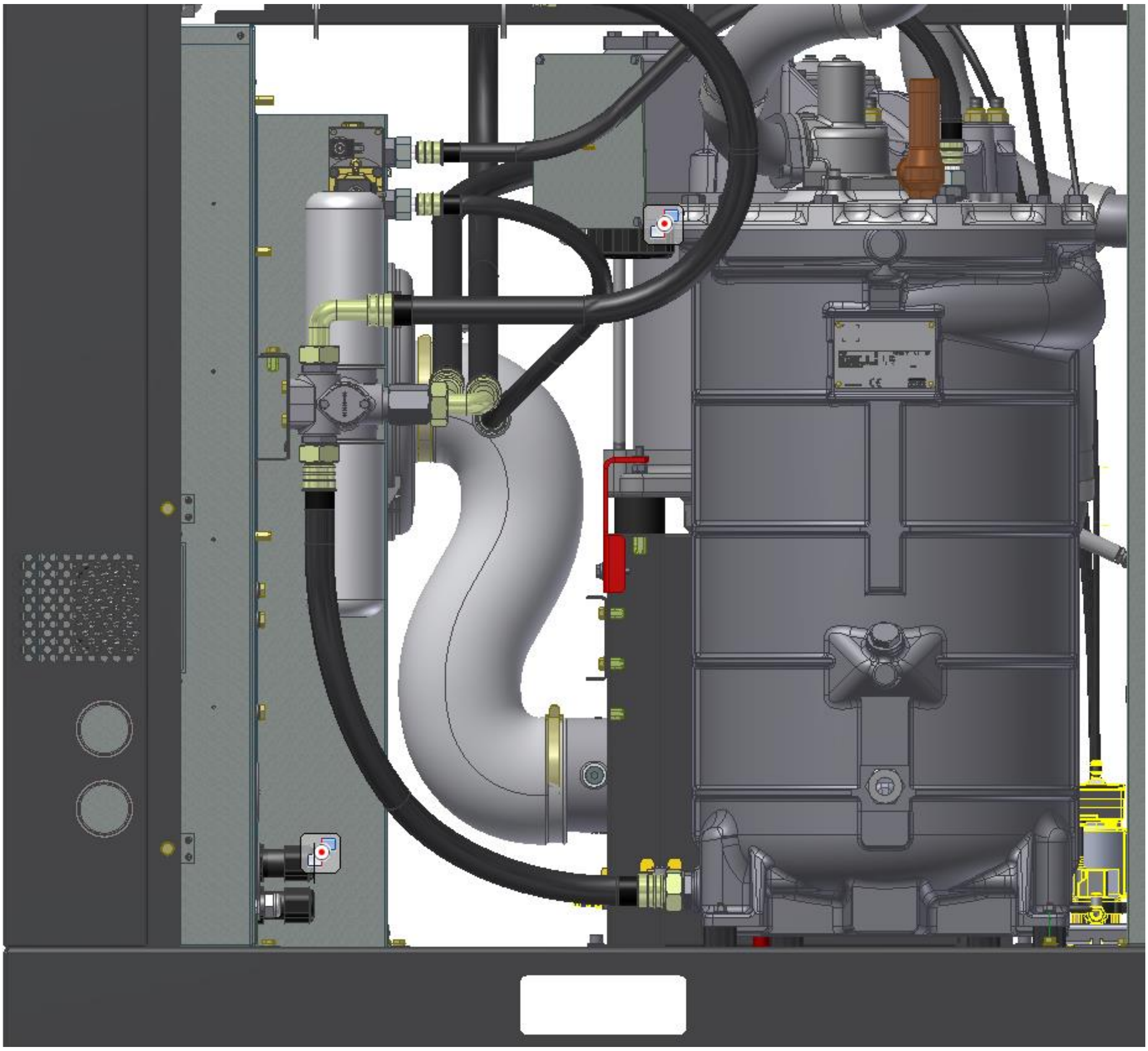

Figure 2: Standard unit

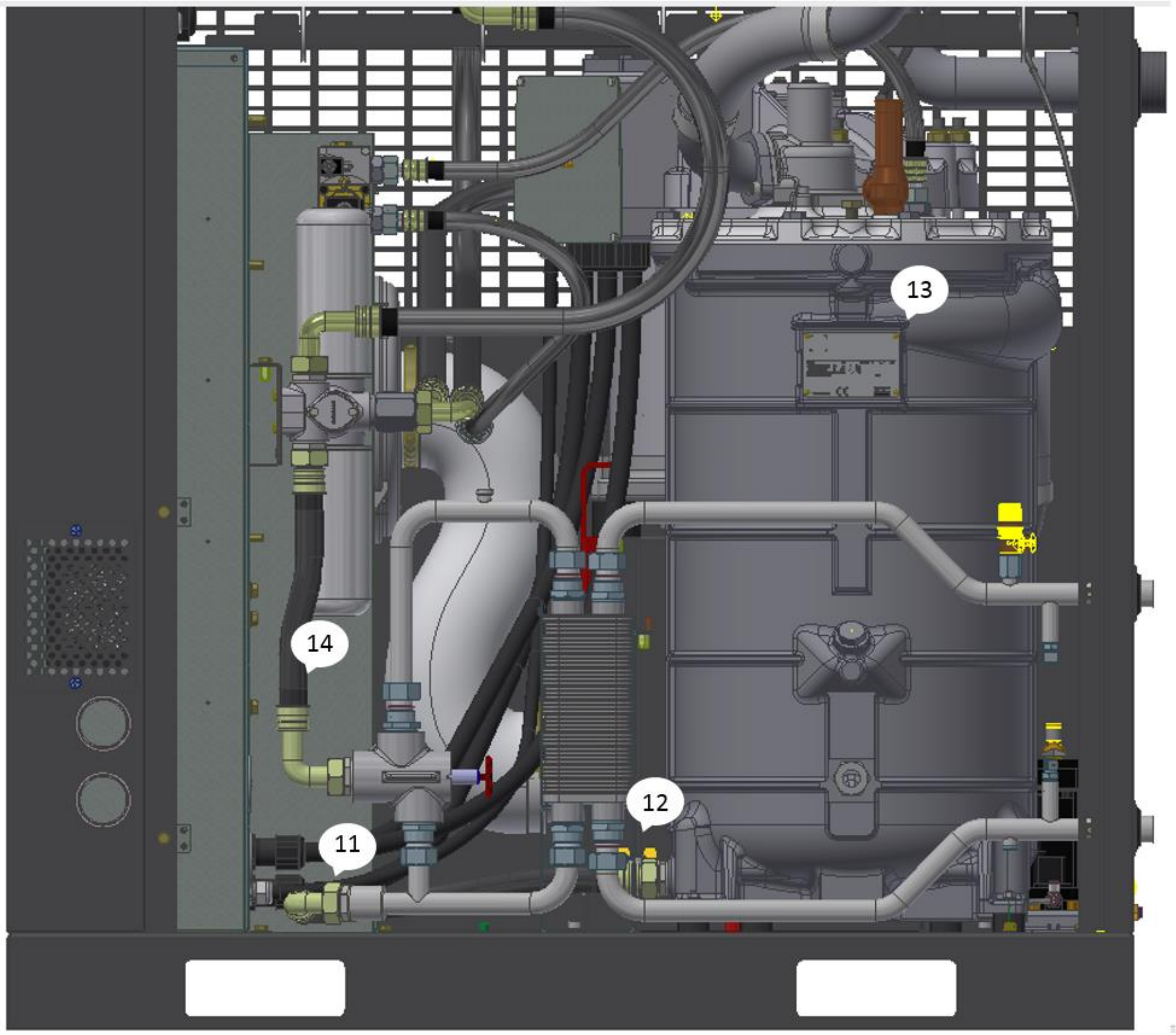

Figure 3: Adaptations energy recovery

Reference in Figure 3	Designation
11	Oil flexible (from vessel to oil inlet oil filter pipe)
12	Oil drain
13	Oil separator vessel
14	Oil flexible (from 1st bypass valve to 2nd bypass valve)

1.5 Electrical adaptations & installation

For details about electrical installation of the temperature sensors of option energy recovery, see service diagram delivered with main compressor.

1.6 Remarks

The main components are assembled ex-factory as a compact unit (ER-unit) which fits inside the bodywork of the compressor.

In case of factory version, the ER-unit is already installed as described in section 1.4 and 1.5

Of course, for the sales version of the ER-unit, the above mentioned mechanical & electrical adaptations still have to be done before the ER-unit can be integrated.
It is recommended to exchange the oil filters when installing the energy recovery.

2 Applications for energy recovery system

2.1 General

The energy recovery system can be applied as low temperature rise/high water flow systems or as high temperature rise/low water flow systems.

2.2 Low temperature rise/High water flow (closed water recovery systems)

For this type of application, the temperature difference between the water in the energy recovery system and the compressor oil is low. Therefore, a high water flow is needed for maximum energy recovery.

Example: The heated water is used to keep another medium at a moderately high temperature, in a closed circuit, e.g. central heating.

2.3 High temperature rise/low water flow (open water recovery systems) [1]

For this type of application, a high water temperature rise in the energy recovery system is obtained, which consequently brings on a low flow rate.

Example: An open circuit where cold water from a main supply is heated by the energy recovery system for use in the factory, e.g. preheating of boiler feed water.

2.4 Recovery water flow

The recovery water enters the ER-unit at *water inlet connection*. In the *heat exchanger* the compression heat is transferred from the compressor oil to the water. The water leaves the *heat exchanger* through the *water outlet connection*.

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[1] The decreasing of water flow to get higher water outlet temperatures will result in higher oil injection temperatures up to maximum 75°C. At that temperature the 2nd bypass valve will make sure the oil injection temperature won’t rise above 75°C. (See section 3 for working). The higher oil injection temperature will have negative effect on the performance of the compressor. Therefore, AML of option tropical thermostat should be applied when using the energy recovery in ‘high temperature rise/low water flow’ type of applications.

2.5 Recovery water requirements for closed water circuits

When the Energy Recovery system is integrated in a closed recirculation water circuit, the use of soft or even demineralised water is economically feasible and eliminates the problems of scale deposits. Although the heat exchanger of the ER-unit is completely made of stainless steel, the water circuit connected to the compressor may require corrosion inhibitors. Consult the table below to minimise problems due to bad water quality. If you have doubt, consult Atlas Copco.

Add an anti-freeze product such as ethylene-glycol to the water in proportion to the expected temperature to avoid freezing. Be aware of it that adding ethylene-glycol to the cooling water will reduce the heat capacity of the cooling medium. The heat capacity of ethylene-glycol is only 61.2% of that of water. So in order to have a similar cooling performance the cooling media flow rate needs to be increased. (Example: if the cooling medium contains x% glycol in 100-x% water, the cooling medium flow rate must be increased with $38.8 \cdot x/(100 - 0.388 \cdot x)$% compared to 100% water)

2.6 Recovery water requirements for open water circuits

For open, non-recirculation water circuits, the major problems usually encountered are related to deposit control, corrosion control and microbiological growth control. To minimize these problems, the water should meet a number of requirements. If in any doubt, consult Atlas Copco.

Recommended maxima (mg/l)	Closed water circuit	Open water circuit
Chloride (Cl^-)	< 600	< 150
Sulphate ($SO4^-$)	< 400	< 250
Total solids	< 3000	< 750
Suspended solids (as SiO_2)	< 10	< 10
Free chlorine (Cl_2)	< 4	< 2
Ammonia (NH_4^+)	< 0.5	< 0.5
Copper	< 0.5	< 0.5
Iron	< 0.2	< 0.2
Manganese	< 0.1	<0.1
oxygen	< 3	< 3
Carbonate hardness (as $CaCO_3$)	50-1000	50-500
Organics ($KMnO_4$ Consumption)	< 25	< 10

3 Operation

3.1 Thermostatic bypass valves

The compressor oil flow is controlled by two thermostatic bypass valves, ensuring reliable compressor operation and optimum energy recovery.

The *1st bypass valve* is integrated in the ER-unit and controls the working of the oil *heat exchanger* of the ER-unit. The *2nd bypass valve* is integrated in the *oil filter housing* and controls the working of the *main oil cooler* of the compressor. Both bypass valves consist of an insert (thermostat) mounted in a housing. For the 1st bypass valve of the ER-unit, this is a single housing. For the 2nd bypass valve of the compressor, this housing is integrated with the *oil filter.*

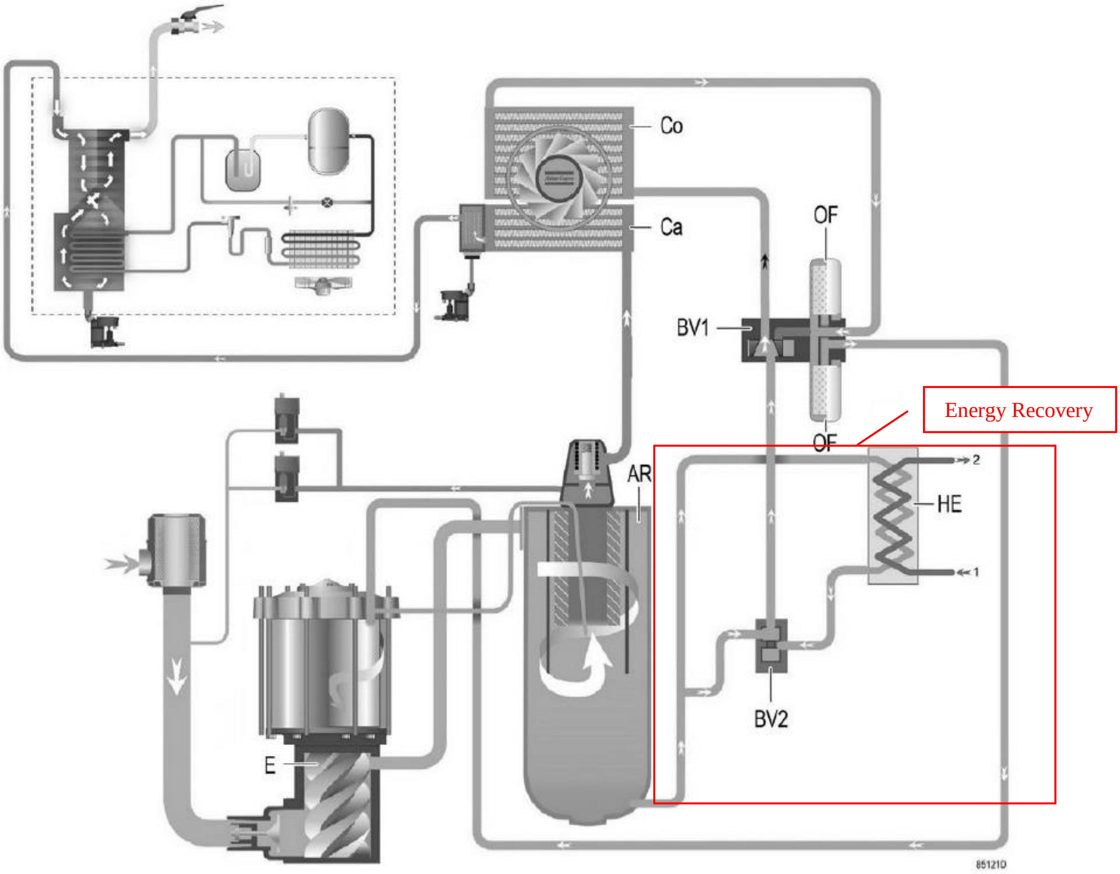

Figure 4: Flow diagram of compressor with energy recovery system

3.1.1 Heat exchanger bypass valve (of ER-unit)

The *1st bypass valve* starts closing the bypass line and opening the oil supply line from the *heat exchanger* of ER-unit at the lower limit of its temperature range; at the upper limit of its temperature range, the bypass line is completely closed and all the oil flows through the ER heat exchanger. The following table shows which thermostat is installed in the bypass valve of the ER.

Range	Variants	Thermostat in bypass valve of ER
GA75-110VSD+	VSD	**60°C** / 60-80°C[1]

GA75-110VSD+

For the references, see Figure 6.

The *1st bypass valve of the ER (7)* is provided with a special *handle (25)*. This handle controls the working of the energy recovery system.

As you can see on the *ER label (*Figure 5*)*, the ER-unit is integrated in the oil circuit and will recover energy when the handle is turned in clockwise.

When the handle is turned out anticlockwise, the ER-unit is bypassed in the oil circuit and will not recover energy.

Attention: It is only allowed to turn the *handle (25)* totally in or out. No position between the main ones is allowed!

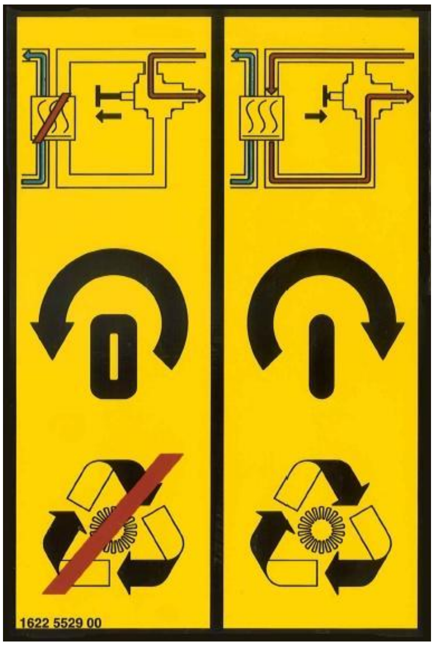

Figure 5: ER label

[1] 60°C/60-80°C: 60°C is the thermostat mark; 60-80°C is the temperature range of the thermostat.

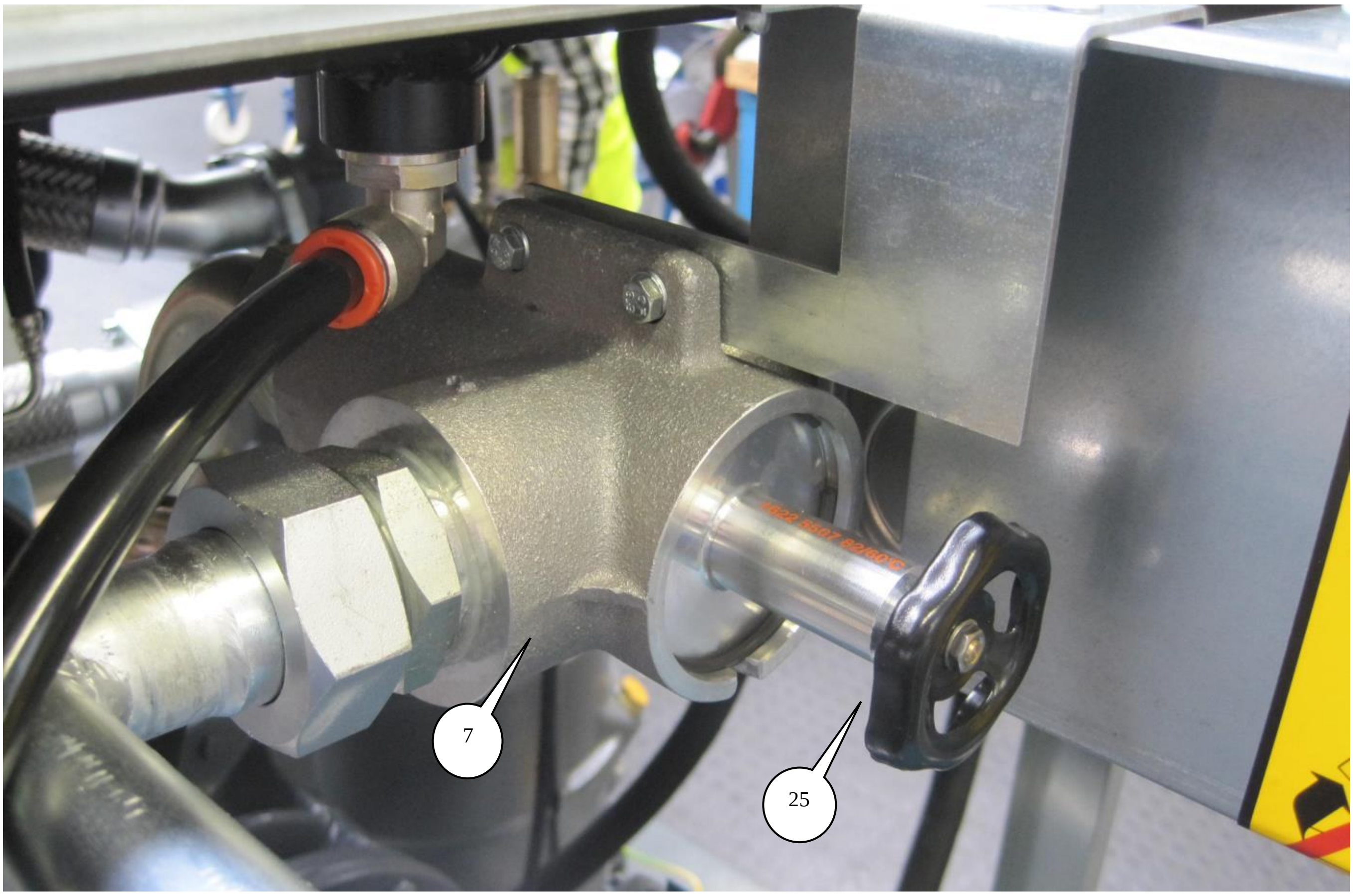

Figure 6: Detail of ER-unit bypass valve with handle (1st bypass valve)

3.1.2 Main oil cooler bypass valve

The *2nd bypass valve* starts closing the bypass line and opening the oil supply line from the *main oil cooler* at the lower limit of its temperature range; at the upper limit of its temperature range, the by-pass line is completely closed and all the oil flows through the main oil cooler.

On all compressors (GA fixed speed and VSD compressors), a thermostat with a higher temperature range (compared to the standard thermostat) is required in the 2nd bypass valve of the oil filter housing when using the compression heat as source for energy recovery. The following table shows which thermostat is installed in the bypass valve of the oil filter housing.

Range	Variants	Thermostat in bypass valve of main oil cooler
GA75-110VSD+	VSD	**75°C** / 75-90°C

In case of a sales version, the standard thermostat in the oil filter pipe (14) has to be replaced by the one marked 75°C delivered with the energy recovery kit.

3.2 Relief valves

For the E.R. systems, a relief valve with a pressure setting of 10 bar is added to the water circuit. This valve will prevent a water pressure of 10 bar and higher from occurring. The E.R. cooler itself has a design pressure of 16bar. If the customer has a water circuit with a pressure between 10 and 16 bar, this valve has to be exchanged with a relief valve with a higher set pressure (between 10 and 16 bar).

3.3 Energy recovery system is turned on

In this case, the *handle (25)* of the *1st bypass valve (7)* of the ER-unit has to be totally turned in **clockwise**.

Attention: It is only allowed to turn the *handle (25)* totally in or out. No position between the main ones is allowed!

3.2.1 Compressor start-up

When the compressor is started up in cold conditions, the oil temperature will be low. The *1st Bypass valve* of the ER-unit shuts off the oil supply from the *heat exchanger* and the *2nd bypass valve* shuts off the oil supply from the *main oil cooler* to prevent the compressor oil from being cooled. The oil flows from the *separator* through the *oil filter* to the *compressor element*.

All energy input is used to rapidly warm up the compressor oil. No energy is recovered.

3.2.2 Maximum energy recovery

When the oil temperature reaches approx. 60°C[1], the *1st bypass valve* of the ER-unit starts opening the oil supply line from the *heat exchange*. If the oil temperature rises to approx. 80°C, all the oil passes through the heat exchanger. The oil from the heat exchanger outlet flows via the *oil filter*, the *compressor element* and the *separator* back to the inlet of heat exchanger. The ***2nd*** *bypass valve* bypasses the *main oil cooler* as long as the oil temperature after the *heat exchanger* remains below 75°C[2].

The heat exchange between the compressor oil and the heat recovery water is maximum.

3.2.3 Low consumption of recovered energy

In this case, the temperature of the oil leaving the *heat exchanger* may be too high for the oil to be injected into the *compressor element*. Therefore, the *2nd bypass valve* will open the oil supply line from the *main oil cooler* to allow the hot oil to be cooled in this cooler.[3]

The amount of energy supplied to the water is adapted to the need of energy.

3.2.4 Recovery water flow too high or water inlet temperature too low

In this case, the temperature of the oil leaving the *heat exchanger* may be too low for the oil to be injected into the *compressor element.* Therefore, the *1st bypass valve* of the ER-unit will partly shut off the oil supply from the *heat exchanger* to allow the cold oil from the heat exchanger to be mixed with the hot oil from the *separator*.

Energy is transferred from the compressor oil to the water, but at a relatively low temperature level.

3.3 Energy recovery system is turned off

Except for the opening temperature of the *2nd by-pass valve* of the *oil filter housing*, the oil system is the same as without installation of the energy recovery unit.

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[1] The opening temperature depends on which insert is placed in the 1st bypass valve of ER-unit.

[2] When leaving the factory, this is 75°C for units. If necessary, this temperature can be adapted by placing another thermostat in the 2nd bypass valve (integrated in the oil filter housing). See also footnote 4 below.

[3] If the *2nd bypass valve* regulates the oil temperature, it will result in higher (75°C) oil injection temperature into the compressor element. This will have negative effect on the performance of the compressor. AML of option tropical thermostat should be applied. Please see also section 2.3.

No energy is recovered.

This situation should be considered as exceptional, e.g. in case of maintenance on the water circuit of the energy recovery unit or when no energy is required for a long period.

3.4 Turning on/off the energy recovery system

3.4.1 For VSD compressors:

Close the air outlet valve and run the unit at minimum speed for a few minutes before switching on/off the energy recovery unit by turning in/out the *handle*.

3.5 Stopping the ER-unit for a long period

In case of an open water system and if freezing temperatures can be expected, isolate the water system of the ER-unit and blow it through with compressed air.

4 Maintenance

4.1 Compressor oil

Oil change:

1. Check if the energy recovery system is turned on.
2. Run the unit until warm. Stop the unit, switch off the isolating switch and close the air outlet valve.
3. Depressurise the compressor and drain the oil of oil separator by opening the *oil drain valve.* See section “Oil and oil filter change” of the instruction book of the main compressor.
4. Draining of ER-unit:
   Detach the *extra oil drain nipple* of the ER-unit to drain the *heat exchanger* of the ER-unit. Reinstall and tighten this nipple after draining.
5. Resume oil change as described in section “Oil and oil filter change” of the instruction book of the main compressor. Use always RXD oil when option ER is installed, for other oils, consult Atlas Copco.

4.2 Thermostatic by-pass valves

The inserts (thermostats) should be replaced by new ones every 8000 hours. Examples: insert is blocked and/or broken, regulating temperature is not within normal range.

4.3 Heat exchanger

If the temperature rise over the energy recovery system declines over a period of time with the same basic working conditions, the *heat exchanger* should be inspected. To clean the oil side, soak the heat exchanger in a degreasing solution. To remove scale formation in the water compartment, a proper descaling process should be applied. Consult Atlas Copco.

5 Energy recovery data

5.1 Reference conditions

Air inlet temperature…………………..............................	°C	20
Absolute air inlet pressure…………………………………	bar	1

5.2 Effective working pressure

- 7.5 bar units……………………………………………...	bar	7
- 10 bar units………………………………………………	bar	9.5
- 13 bar units……………………………………………...	bar	12.5
- 100 psi units……………………………………………...	psi	100
- 125 psi units……………………………………………...	psi	125
- 150 psi units……………………………………………...	psi	150
- 175 psi units……………………………………………...	psi	175

5.3 Maximum working pressure

Oil side……………………………………………………..…	bar	15
Water side……………………………………………………	bar	10

5.4 Reading settings

To read a setting, consult section Elektronikon in the instruction book of compressor. In addition to other data, the following temperatures can be read by pressing the scroll key:

- The water inlet temperature of the ER-unit.
- The water outlet temperature of the ER-unit.

5.5 Modifying settings

If the programmed warning settings for the water temperatures are exceeded, a warning indication is shown on the compressor control module:

Temperature input	Unit	Min. setting	Nom. setting	Max. setting
Energy recovery water inlet	°C	0	70	99
Delay at warning signal	sec	0	Consult Atlas Copco	255
Delay at start should be less than delay at warning signal	sec	0	Consult Atlas Copco	255
Energy recovery water outlet	°C	0	90	99
Delay at signal	sec	0	Consult Atlas Copco	255
Delay at start should be less than delay at warning signal	sec	0	Consult Atlas Copco	255

To modify a setting, consult section Modifying parameters in the instruction book of compressor.

5.6 Recoverable energy

The recoverable energy can be calculated by using the following formula:

RECOVERED ENERGY (kW) = 4,2 x water flow (l/s) x water temperature rise (°C)

The maximum recoverable energy is approx. 75% of shaft power of the compressor.
If you compare with the electrical input power the percentage will be lower for air cooled compressors because the fan requires also some electrical energy witch is not recoverable.
For VSD compressors the recoverable energy is also a little lower because the drive also requires some electrical energy witch is not recoverable.

5.7 Data for low temperature rise/high water flow systems

In the tables below, typical values are given for the above mentioned type of water flow system.

5.7.1 GA75-110 VSD+ range

Parameters	**Unit**	**GA75VSD+ 7bar 3150RPM**	**GA90VSD+ 7bar 3666RPM**	**GA110VSD+ 7bar 4200RPM**
Recoverable energy	kW	69,9	85,8	97,7
Recoverable energy	hp	93,7	115,1	131,0
waterflow	l/min	65,5	80,5	91,6
waterflow	cfm	2,31	2,84	3,23
Temperature at inlet	°c	55	55	55
Temperature at inlet	°F	131	131	131
Temperature at outlet	°C	70	70	70
Temperature at outlet	°F	158	158	158
Input power motor shaft	kW	86,5	102,4	119,3
Percentage Energy recovered	%	80,8	83,8	81,9

5.8 Data for high temperature rise/low water flow systems [1]

In the tables below, typical values are given for the above mentioned type of water flow system.

5.8.1 GA75-110VSD+ range

Parameters	Unit	GA75VSD+ 7bar 3150RPM	GA90VSD+ 7bar 3666RPM	GA110VSD+ 7bar 4200RPM
Recoverable energy	kW	53,7	73,4	87,8
Recoverable energy	hp	72,01	98,43	117,74
waterflow	l/min	11,5	15,1	17,7
waterflow	cfm	0,4	0,5	0,6
Temperature at inlet	°c	20	20	20
Temperature at inlet	°F	131	131	131
Temperature at outlet	°C	87	90	90
Temperature at outlet	°F	158	158	158
Input power motor shaft	kW	64,2	84,3	98,8
Percentage Energy recovered	%	83,7	87,1	88,9

5.9 Conversion list of SI units into British/US units

1 bar = 14,504 psi
1 l/min= 0,035 cfm
1 kW = 1,341 hp
x °C = (32 + 1,8x) °F

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[1] Please keep in mind that this type of application can have negative effect on the compressor performance. See section 2.3 for any details.